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# The recruitment pattern of *Macrobrachium amazonicum* (Crustacea, Decapoda, Palaemonidae) in two areas of the Amazon River mouth, Amapá State, Brazil

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**ABSTRACT.** *Macrobrachium amazonicum* is an indigenous prawn vastly distributed in basins of South America, widely exploited by artisanal fisheries in northern and northeastern Brazil and, with great potential for aquaculture. The recruitment pattern of *Macrobrachium amazonicum* at the Amazon River mouth, State of Amapá was studied for a period of twelve months from January to December of 2009. In this work, 5092 specimens were captured at the two selected sites. The sex ratios obtained in both sites were similar with 1 male to 1.46 females and 1 male to 1.31 females, respectively. The smallest captured specimens measured 10.07 mm. About 91% of juveniles, between 23.00 mm and 33.00 mm of standard length, integrated for the first time the exploitable stock. Ovigerous females of *M. amazonicum* were found during the entire year; however, the peak reproductive period was December to April when 18 to 34% of the females were ovigerous, coinciding with higher rainfall. The presence of ovigerous females and juvenile shrimps throughout the year observed in the Amazon River suggests that recruitment of *M. amazonicum* was continuous and that breeding activity is all year round. The recruitment pattern of *M. amazonicum* occurred throughout the year, showing a major peak in the month of July. The growth parameters obtained for the recruited prawns were $L\infty = 95$ mm of standard length, $K = 0.83$ cm.month$^{-1}$, $C = 1.0$, $WP = 0.6$ and $t0 = 0$. The size and number of juvenile shrimps caught in this study indicates that the traps in use has very closed cracks and can be affecting the local structure of *M. amazonicum* populations, given the considerably decreased volume and size of shrimps caught reported by local fishermen. The size at first maturity and number of juvenile prawns caught for *M. amazonicum* in the present study, suggested that the minimum size of capture is is between 60.0 and 70.0 mm.

**Keywords:** Amazon Region; prawns fishing; reproduction; juvenile prawns.

## O padrão de recrutamento de *Macrobrachium amazonicum* (Crustacea, Decapoda, Palaemonidae) em duas área da foz do Rio Amazonas, Amapá, Brasil

**RESUMO.** *Macrobrachium amazonicum* é uma espécie nativa vastamente distribuída nas bacias da América do Sul, sendo largamente explorada por pescadores artesanais no Norte e Nordeste do Brasil e com grande potencial para aquicultura. O padrão de recrutamento de *Macrobrachium amazonicum* da foz do rio Amazonas, estado do Amapá foi estudado entre janeiro e dezembro de 2009. Foram capturados e examinados 5.092 exemplares. As proporções sexuais foram similares entre as duas áreas estudas com 1 macho: 1,46 fêmeas e 1 macho: 1.31 fêmeas, respectivamente. Os menores camarões capturados mediram 10.07 mm. Cerca de 91% dos juvenis, que integram pela primeira vez o estoque pesqueiro explorado, apresentam-se entre 23,00 mm e 33,00 mm de comprimento padrão. Fêmeas ovígeras de *M. amazonicum* foram encontradas durante todo o ano inteiro, contudo, o pico de reprodução foi observado entre dezembro e abril, quando 18 a 34% das fêmeas estavam ovígeras, coincidindo com o período chuvoso. A presença de fêmeas ovígeras e camarões juvenis foi observada ao longo do ano no Rio Amazonas sugerindo que o recrutamento de *M. amazonicum* seja contínuo e a atividade povoamento ocorra o ano inteiro. O recrutamento de *M. amazonicum* foi observado o ano inteiro, com um grande pico em julho. Os parâmetros de crescimento obtidos para o recrutamento dos camarões foi $L\infty = 95$ mm de comprimento padrão, $K = 0.83$ cm.mês$^{-1}$, $C = 1.0$, $WP = 0.6$ e $t0 = 0$. O tamanho e o número de camarões juvenis capturados neste estudo indicam que os matapis em uso tem frestas muito fechadas e podem estar afetando a estrutura populacional de *M. amazonicum*, dada a diminuição considerável do volume e tamanho dos camarões capturados relatados pelos pescadores locais. O tamanho da primeira maturação e número de camarões juvenis reportados no presente estudo, sugerem que o tamanho mínimo de captura para o camarão-da-Amazônia esteja entre 60,0 e 70,0 mm.

**Palavras chaves:** Região Amazônica, pesca de camarões, reprodução, *camarões juvenis*.

## 1. Introduction

The genus *Macrobrachium* Bate, 1868 has a worldwide distribution that includes the Americas, with more than 55 recognized species, 17 of which are distributed in Brazil on basins of the inland, the coast and in Amazonia (MANTELATTO et al., 2008; PILEGGI; MANTELATTO, 2010). The reproductive period of *Macrobrachium* species is closely associated with the rainy period, thermal variations and photoperiod of the region where it happens (LIMA et al., 2014). This shrimps are known to exhibit differentiated breeding strategies adapted to the most diverse environments. Coastal species shows females with a large amount of small eggs and larvae, which have several planktonic instars; however, many continental species shows big eggs and abbreviated larval development. Therefore, an understanding of the reproductive periodicity can also be used to determine the minimum number of adults necessary to maintain the recruitment and egg survival rates until adulthood; and is imperative for the development of management, with obvious consequences for species conservation policies (FRANSOZO et al., 2004; DA SILVA et al., 2004).

Recruitment is a complex process involving a chain of events in the life cycle of the prawns (DEEKAE; ABOWEI, 2010). According Pitcher (1982), the recruitment occurs when an age group integrates itself for the first time into the exploitable stock. It is more or less a function of age (or size) when the juveniles grow large enough to stay with the main body of adults. Recruitment depends on where prawns of catchable sizes are located and to some extent this

depends upon the kind of gear and fishing, boats used (DEEKAE; ABOWEI, 2010).

The Amazon River shrimp, *Macrobrachium amazonicum*, exhibits different breeding patterns throughout the Amazon River and its tributaries. In the Amazonia, many scientists have reported several recruitment events for *M. amazonicum* in recent years (ODINETZ-COLLART, 1993; SILVA et al., 2002; SILVA et al., 2005; SILVA et al., 2007). However, the data presented are not conclusive, and further studies are necessary to clarify the recruitment of this species in the different Amazonian populations.

The Amazon River shrimp is widely caught and commercialized in the Amazon region and it serves as a major (and sometimes only) source of animal protein for local residents. Despite its economic value and cultural importance as an ingredient in regional recipes, management of the species is nearly non-existent, due among other reasons, to the gaps in the knowledge regarding its biology and fishing efforts in the natural environment (BENTES et al., 2011). This paper provides first information concerning recruitment of *M. amazonicum* caught using artisanal trap (*matapi*) in the mouth of the Amazon River, State of Amapá.

## 2. Material and methods

*Study area*

The study area comprised the regions of Santana Island (00°03'40.9"S and 051°08'46.6"W) and Mazagão Velho (00°15'39.9"S and 051°20' 42.3'W), located at the estuary of the Amazon River, in the state of Amapá (Figure 1). The areas studied are relatively similar and important to artisanal prawn fishing. They present various drainage channels, with different sizes and depths influenced by tidal flooding, enabling the creation of a wide diversity of microhabitats. In the site of Santana Island, the *vegetation* is open and sparely, with the presence of a narrow border of macrophytes. In the Mazagão Velho site, the vegetation is strongly dense with great and wide bands of macrophytes along of the river.

*Sampling collections*

Shrimps were collected monthly from January 2009 to December 2009, using twenty artisanal traps called "matapi" (PINTO; MOREIRA, 2005; SIMONIAN, 2006). Shrimps were captured under authorization of the Chico Mendes Institute for Biodiversity Conservation (SISBIO No. 17702). The traps were set at depths of 1 to 2 meters, during an average of 12 hours of immersion. This sampling is equivalent to the capture performed by artisanal fishermen, which takes place every tidal cycle (12 hours, twice daily). All captures occurred at dawn during low tide. Shrimps were placed in plastic bags with solution of 4% formalin + 70% ethanol (1:1) for preservation. All shrimps were identified, counted and sexed. Each shrimp had its standard length measured (SL - linear distance from the base of ocular orbit to the base of the telson) with a digital caliper (minimum unit of 0.1 mm).

*Statistical analysis*

The chi-square test was performed to verify differences between the sex ratio.

Based on the time set reproductive higher intensity, individuals were grouped into two categories: immature and mature. Based on this classification, individuals' frequency was calculated to each category class for length (P). The total number of individuals of each of the length groups (lines) were calculated percentages of the respective mature individuals following the method of King (1995), as follows:

$P = 100*1/(1 + EXP [-r (L - Lt)])$

where;

P = Probability of capture

L = Length of fish (shrimp)

r = Slope of the curve

Lt = Mean length at first maturity, i.e. the length corresponding to 50% of adults (sexually mature).

Growth parameters of *M. amazonicum* were estimated using the ELEFAN I routine in FISAT II software (GAYANILO; PAULY, 1997). Asymptotic cephalothorax length (CL∞) and 95% confidence interval (CI) were obtained using the Powell-Wetherall method (WETHERALL, 1986). The recruitment pattern of the shrimps was estimated by using the FiSAT programme (GAYANILO; PAULY, 1997). In this method, recruitment patterns were analyzed by fitting the frequency data for each month and pooling them together for each year.

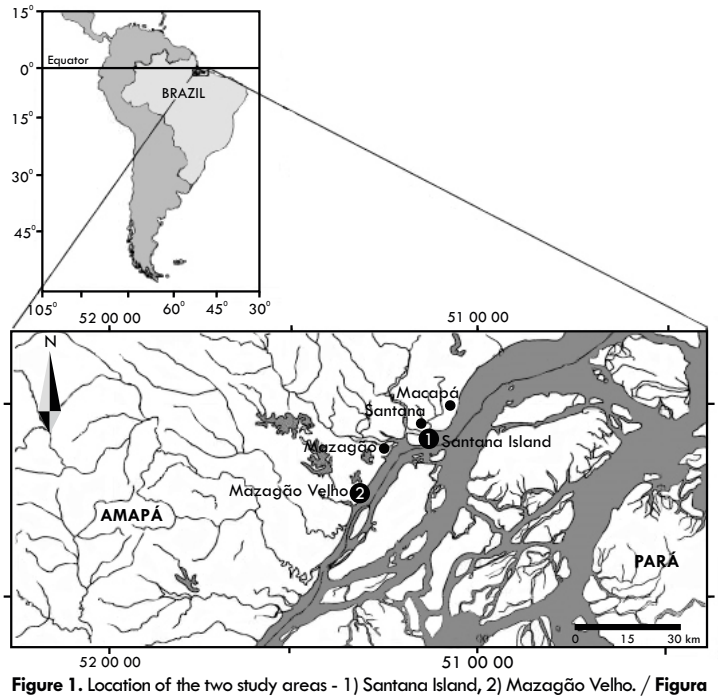


**Figure 1.** Location of the two study areas - 1) Santana Island, 2) Mazagão Velho. / **Figura 1.** Localização das duas áreas de estudo - 1) Ilha de Santana, 2) Mazagão Velho.

## 3. Results

In the present study, 5,092 shrimps were captured. The sex ratios obtained in both study sites were similar with 1 male to 1.46 females and 1 male to 1.31 females, respectively. The mean length was 43.57 mm, the smallest captured shrimps measured 10.07 mm and the largest 93.28 mm, however, about 91% of juveniles integrated for the first time the exploitable stock between the size 23.0 and

33.0 mm of standard length. Ovigerous females of *M. amazonicum* were found during the entire year, however, the peak reproductive period was December to April when 18 to 34% of the females were ovigerous, coinciding with the period of greater rainfall (Figure 2). The recruitment pattern of *M. amazonicum* (Figure 3) showed only one peak per year (in July, 25.5%).

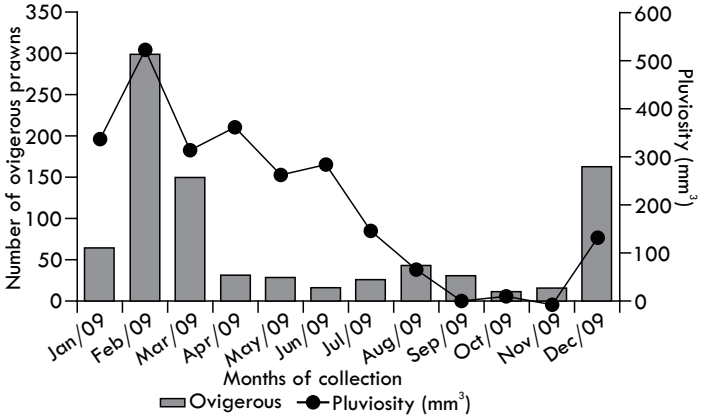


**Figure 2.** Abundance of ovigerous shrimps in Island of Santana and Mazagão Velho according rainfall from January to December of 2009. / **Figura 2.** Abundância de camarões ovígeras na Ilha de Santana e Mazagão Velho, de acordo com a precipitação de janeiro a dezembro de 2009.

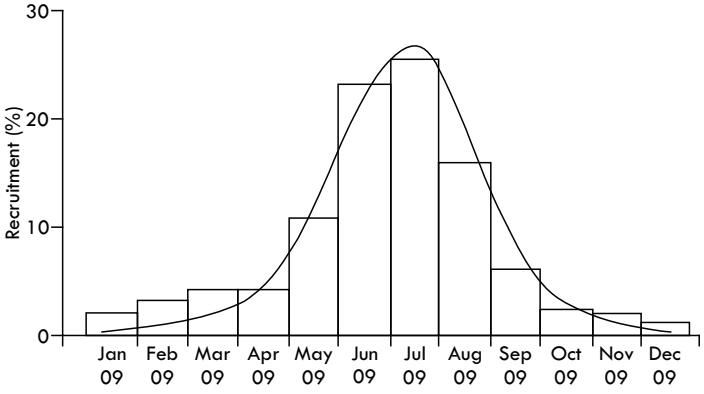


**Figure 3.** Recruitment pattern of *M. amazonicum* in Island of Santana and Mazagão Velho from January to December of 2009. / **Figura 3.** Padrão de recrutamento de *M. amazonicum* na Ilha de Santana e Mazagão Velho de janeiro a dezembro de 2009.

The asymptotic length estimated by the Powell-Wetherall method was 95 mm for sex grouped. The growth coefficients (K) was 0,83 mm/month, the intensity of the (sinusoid) growth oscillations of the growth curve and the onset of the first oscillation relative to t = 0, respectively. The amplitude of oscillation (C) was 1.0, with 0.87 winter point value and t0=0 for sex grouped.

Juveniles, non-ovigerous females and ovigerous females in the present study were observed. There were more females than males in the population and probably this allowed for continuous replacement. The mean length at first maturity for the shrimps was estimated at 64.08 mm.

## 4. Discussion

The presence of juveniles shrimps and ovigerous females throughout the year observed in the Amazon River suggests that recruitment of *M. amazonicum* was continuous and that breeding activity is all year round. In fact, Sastry (1983) observed that shrimps exhibit various spawning patterns depending on the geographical location. Consequently, the majority of tropical shrimps show several spawning peaks per year. This trend has also been reported for *M. macrobrachion* by Marioghae and Ayinla (1995), *M. olfersi* (WIEGMANN, 1836) by Mossolin and Bueno (2002), *Atya scabra* (LEACH, 1815) by Galvão and Bueno (1999), *Rimapenaeus constrictus* (STIMPSON, 1874) by Costa and Fransozo (2004a, b) and in the spine shrimp *Exhippolysmata oplophoroides* (HOLTHUIS, 1948) by Fransozo et al. (2005).

In *M. amazonicum* the peak reproductive period coinciding with the rainy season period as observed by Romero (1982), Odinetz-Collart (1988, 1993), Bragagnoli and Grota (1995), Bialetzki et al. (1997), Porto (1998), Silva et al. (2002), Da Silva et al. (2004), Silva et al. (2005), Silva et al. (2007), Sampaio et al. (2007), Lima et al. (2014) and in the present study (Figure 2). Although the majority of studies reported the reproductive period of *M. amazonicum* coinciding with the rainy season, Sampaio et al. (2007) observed no relationship with atmospheric precipitation in the populations from Jaguaribe River (northeastern Brazil). Thus, there is an indication that this species shows large adaptive capacity and strong physiological plasticity. This study showed more females than males in the population and probably this allows continuous replacement of population in the studied area; hence, the mouth of the Amazon River may be a breeding ground for *M. amazonicum*.

In most cases, shrimps shows production cycles throughout the year but seasonal variations occur. For instance, Garcia (1985) and Reste (1978) reported that penaeid shrimps were more abundant in the dry season than in the wet season. They observed that annual migration of *Farfantepenaeus* (*Penaeus*) *duorarum* (BURKENROAD, 1939) and *Penaeus setiferus* (LINNAEUS, 1767) was related to the rise in temperature in the dry season and consequently high recruitment during this period. Enin (1995) reported two recruitment peaks for *M. macrobrachion* in Cross River estuary, in the months of December and June. Deekae and Abowei (2010) studying populations of same species in Luubara Creek, also observed two recruitment peaks in the months of March and October. Waribugo (2005) reported that recruitment of *Nematopalacmon hastatus* (AURIVILLIUS, 1898) and *Palaemon maculatus* (THALLWITZ, 1892) in the River Nun estuary also had two peaks, which occurred in July and November and September and February, respectively. In populations of *M. iheringi* from Buava River and Botucatu region, state of São Paulo, the recruitment occurred particularly during summer (less rainy months) (LOBÃO et al. 1986, FRANSOZO et al. 2004). In the present study, the juvenile recruitment was observed during the entire year similar to that reported by Odinetz-Collart (1993), Silva et al. (2002), Silva et al. (2005) and Silva et al. (2007). However, none of the authors found recruitment patterns similar to those observed in the present study, where it is clearly seen a peak formed in July. One can deduce that the recruitment between species and among the populations of a same species may be influenced by environmental conditions and geographical characteristics.

Taking into account that 70.7 % of juveniles of *M.*

*amazonicum* integrate for the first time into the exploitable stock between sizes 9.09 mm and 11.09 mm of carapace length, one can deduce that the traps currently used may be affecting the local population and implying negatively the natural stocks in the Amazon region. Similarly Silva et al. (2007) evidenced that the current fishing pressure affects the population of *M. amazonicum* at the Combú Island, state of Pará. Thus, based on the data presented by Pinto (2005) and Camargo et al. (2009) it is suggested the adjustment of the minimum distances of 8 and 10 mm between the splints of *matapis*, replacing the currently used distance of 2.0 mm to 5.0 mm by artisanal fishermen in the Amazon region. The size at first maturity for *M. amazonicum* between 45.0 mm to 60.0 mm of total length reported by Guest (1979); Moraes-Riodades and Valenti (2002); Silva et al. (2005); Sampaio et al. (2007) and Lima et al. (2014), they were lower than found in this study suggested that the prawns still have a good size, it is still necessary that the first catch size is between 60.0 and 70.0 mm.

## 5. Conclusions

Although there juveniles and ovigerous females all year, determining that the recruitment and reproduction for this species is constant, but with a very clear peak for recruitment during the year. As the seasonality of the region affects the dynamics of the species, amplitude of seasonal growth oscillations was great.

Size and number of juveniles shrimps obtained in the present study indicate that Matapis currently used may be affecting the local population and compromise the natural stocks in the Amazon region. The adjustment of the minimum distances between the splints of traps, replacing the currently used distance by artisanal fishermen in the Amazon region is necessary.

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